



Urban and Rural Temperature Trends in Proximity to Large U.S. Cities: 1957-2006

Presentation to the 2nd International Conference on
Countermeasures to Urban Heat Islands

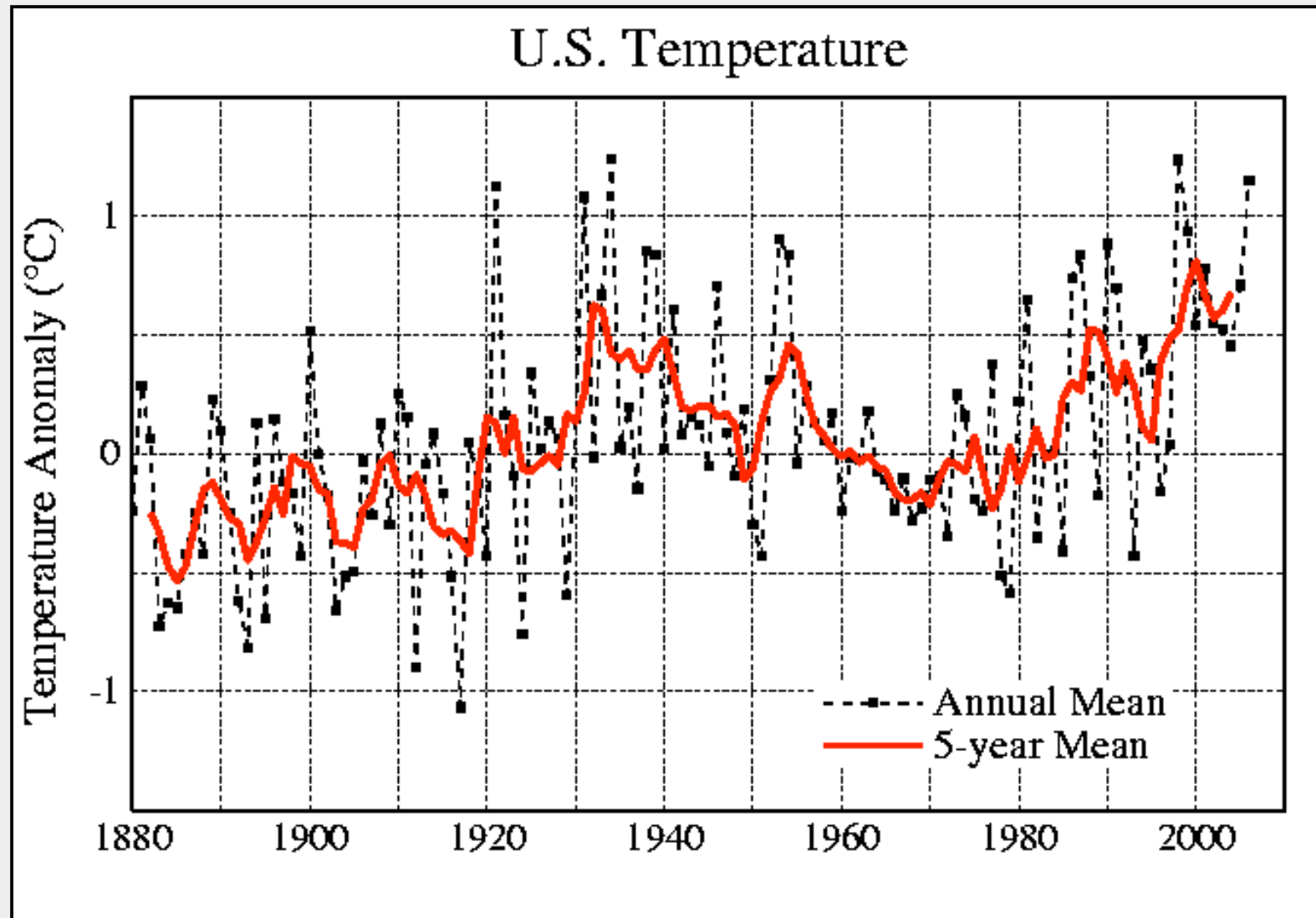
Brian Stone, Ph.D.
Associate Professor
City and Regional Planning Program
Georgia Institute of Technology
stone@gatech.edu

September 21, 2009



Overview

- ❖ Measuring climate change
- ❖ Study design
- ❖ Urban and rural temperature trends
- ❖ Implications for heat island management

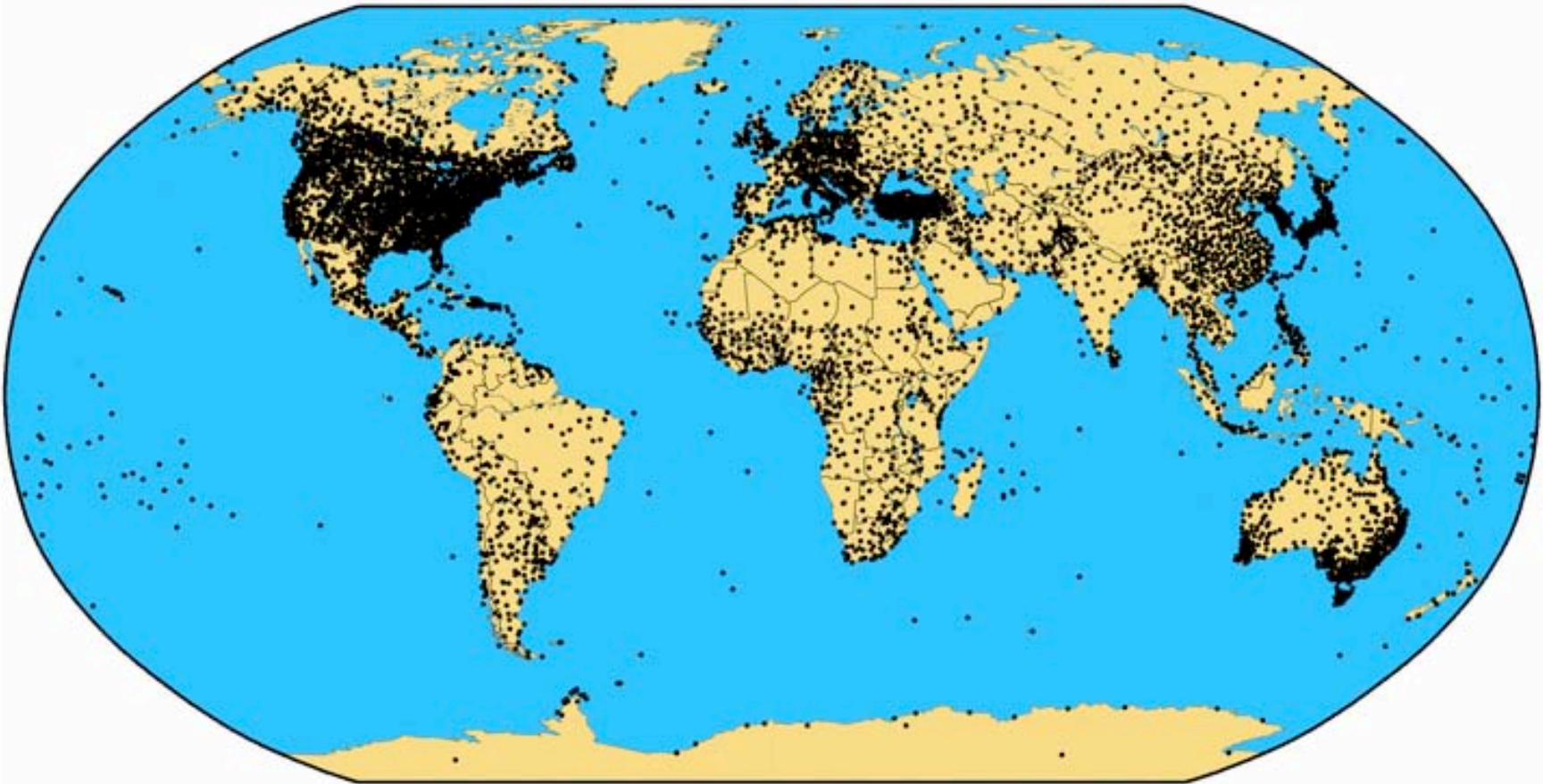


Source: NASA Goddard Institute for Space Studies



Global Historical Climatology Network

Figure 1: GHCN-Monthly Coverage Map for Mean Temperature



Source: GISS, 2007.



Sources of “Inhomogeneity” in Temperature Record

1. Change in location of instrument
2. Change in instrumentation
3. Change in time of observation
4. Contamination by urbanization

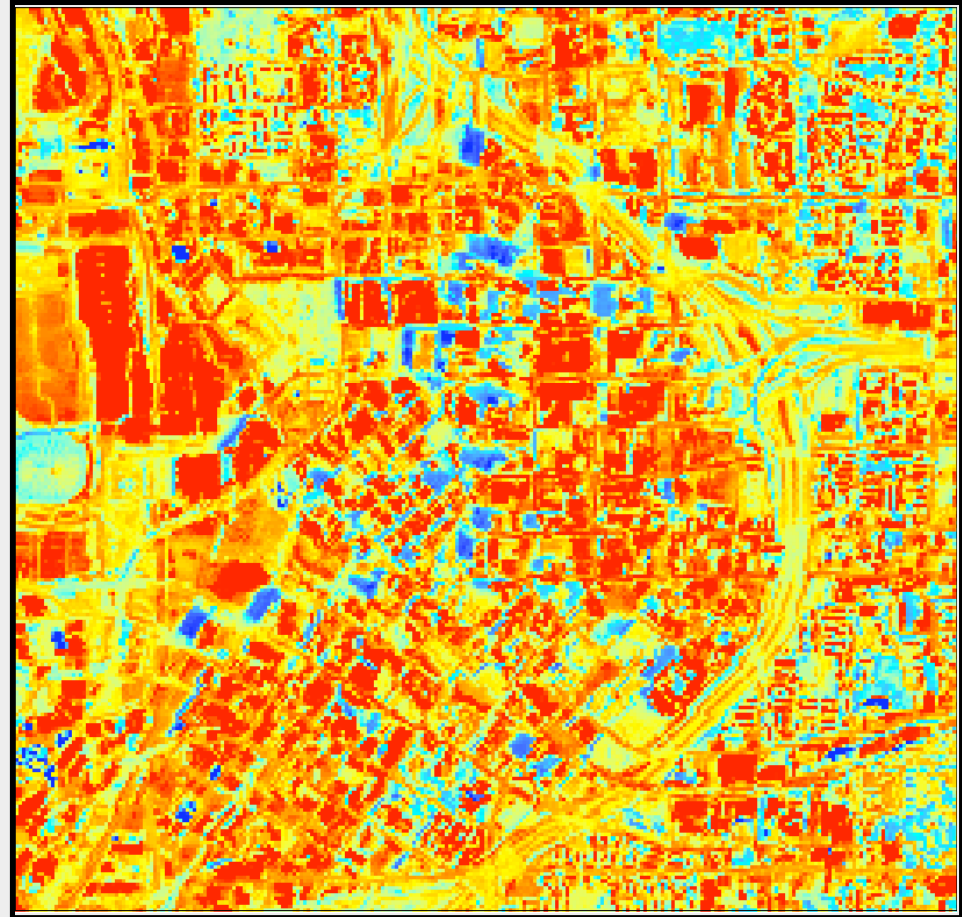




Research Question

The IPCC projects a range of increase in mean global temperatures of between 1.4 and 5.8 °C by 2100.

Are large U.S. cities warming more rapidly than the planet as a whole?



Intensity of surface heat in Atlanta's CBD, 1997



Station Selection

URBAN

- ➔ Airport as single “first-order” meteorological station for each urban center
- ➔ Night light ranking of C (bright)

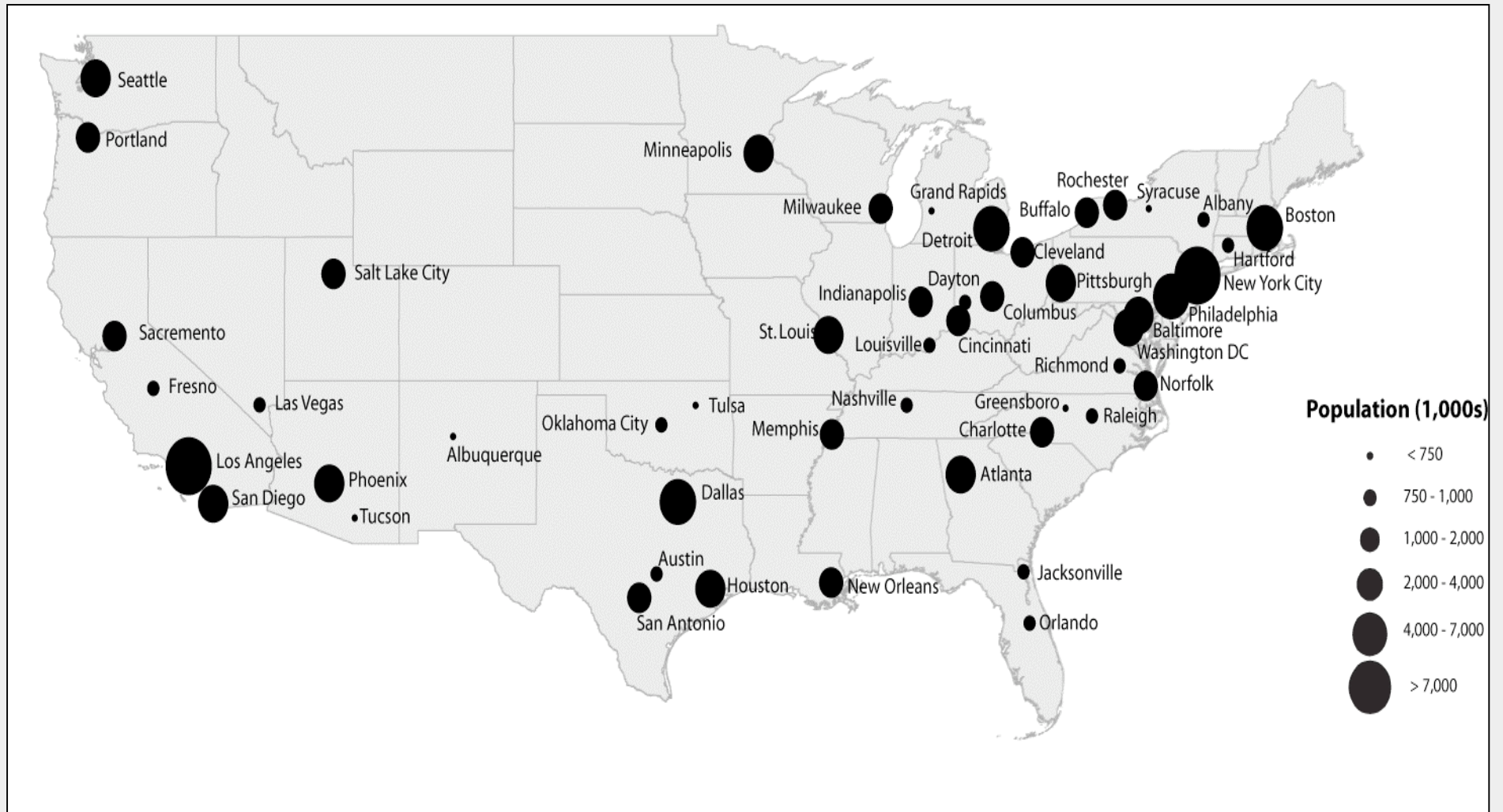
RURAL

- ➔ Three stations selected for each city based on:
 1. Night light ranking of A (dark) or B (dim)
 2. Population < 4,000 per square kilometer
 3. Located within 50 to 250 km of urban station



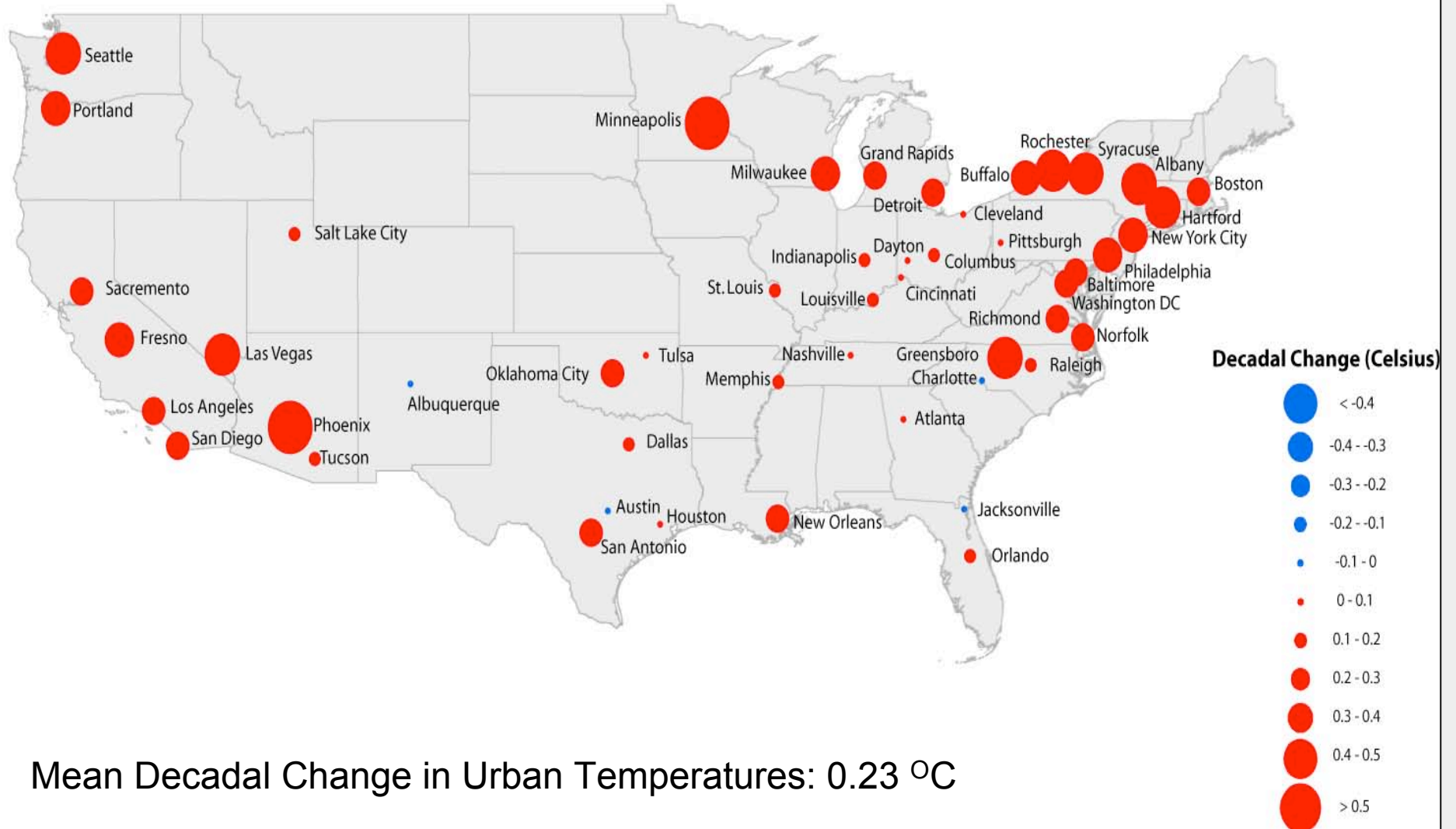


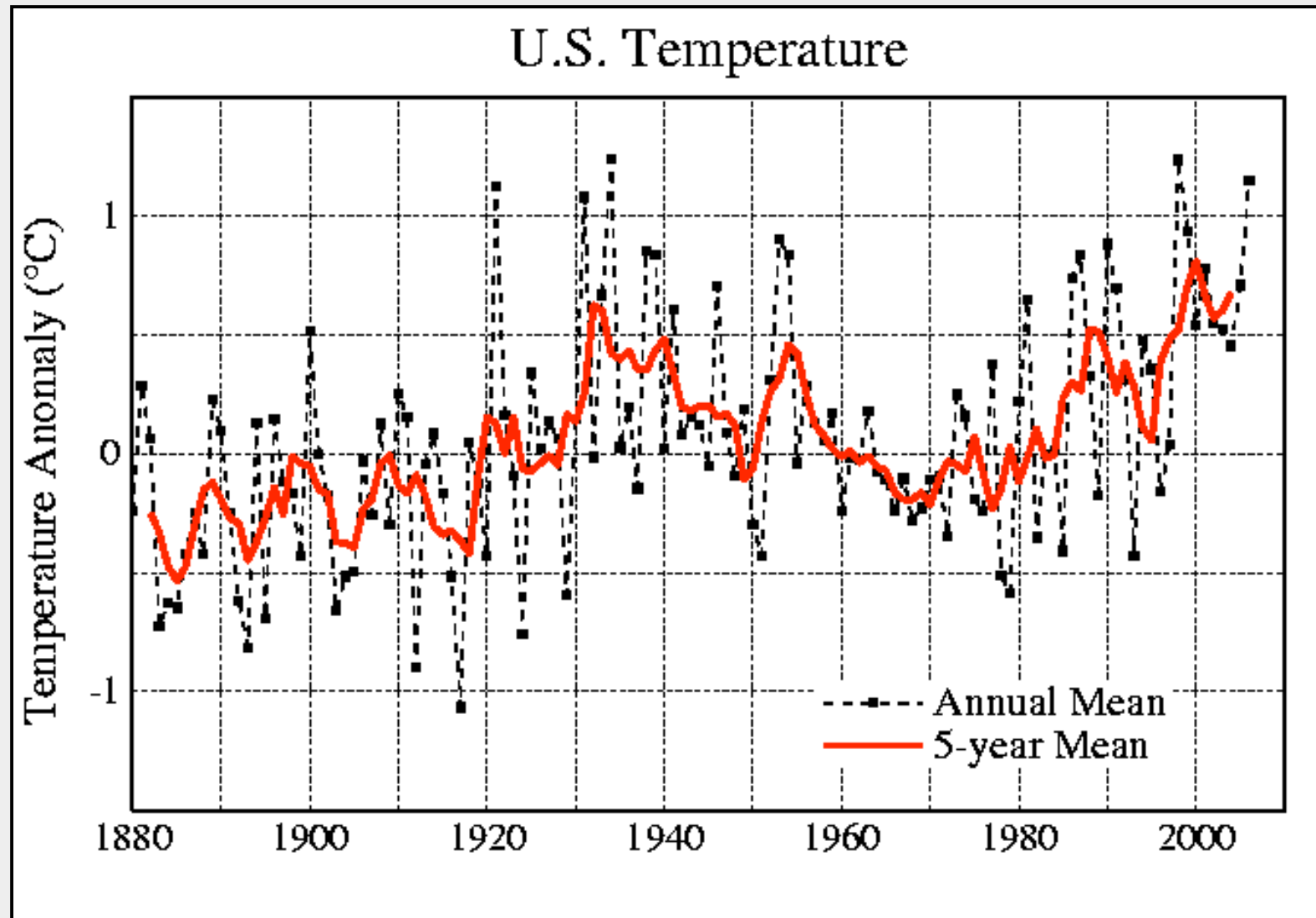
50 Cities Included in Study



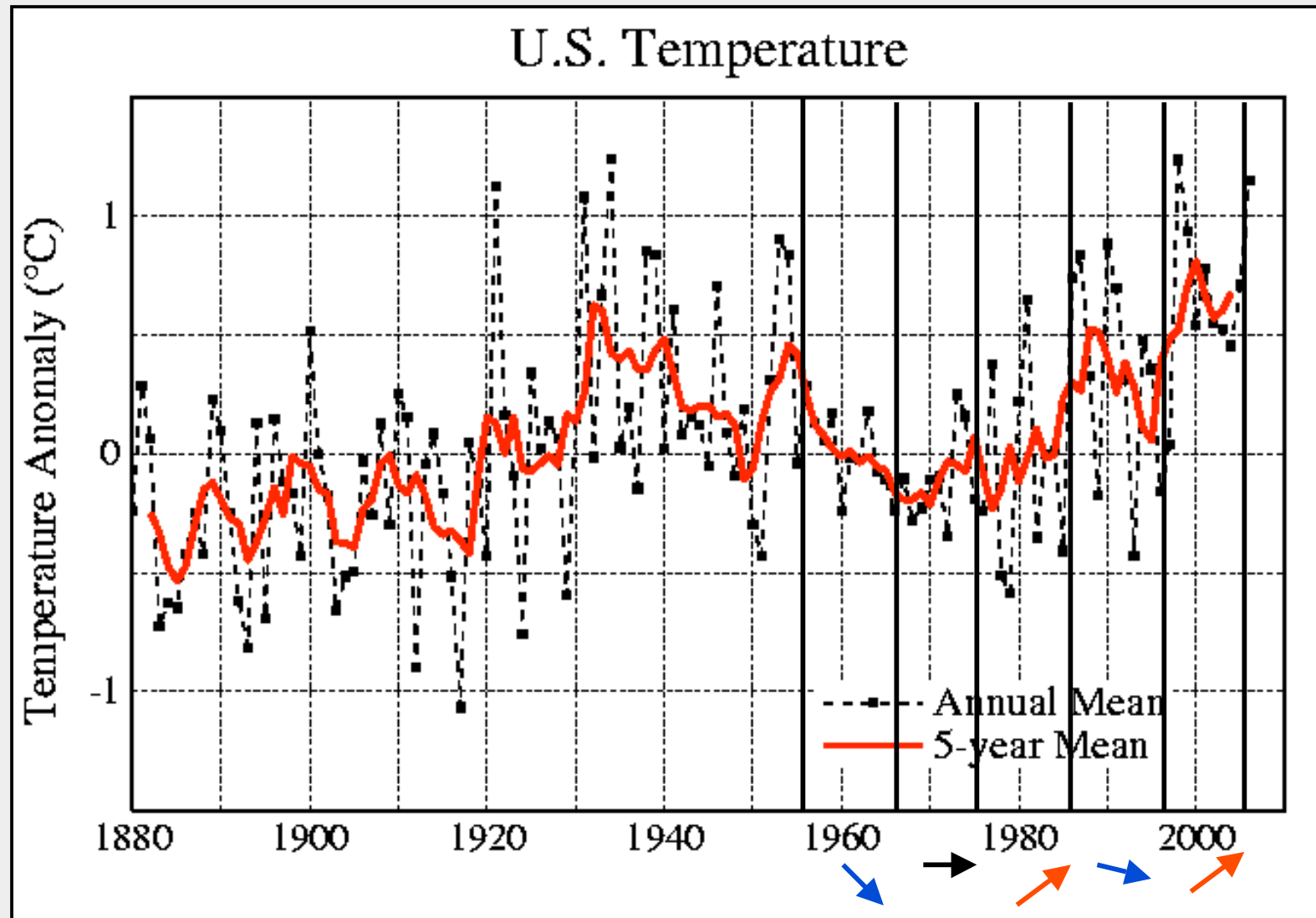


Urban Trends: 1957-2006





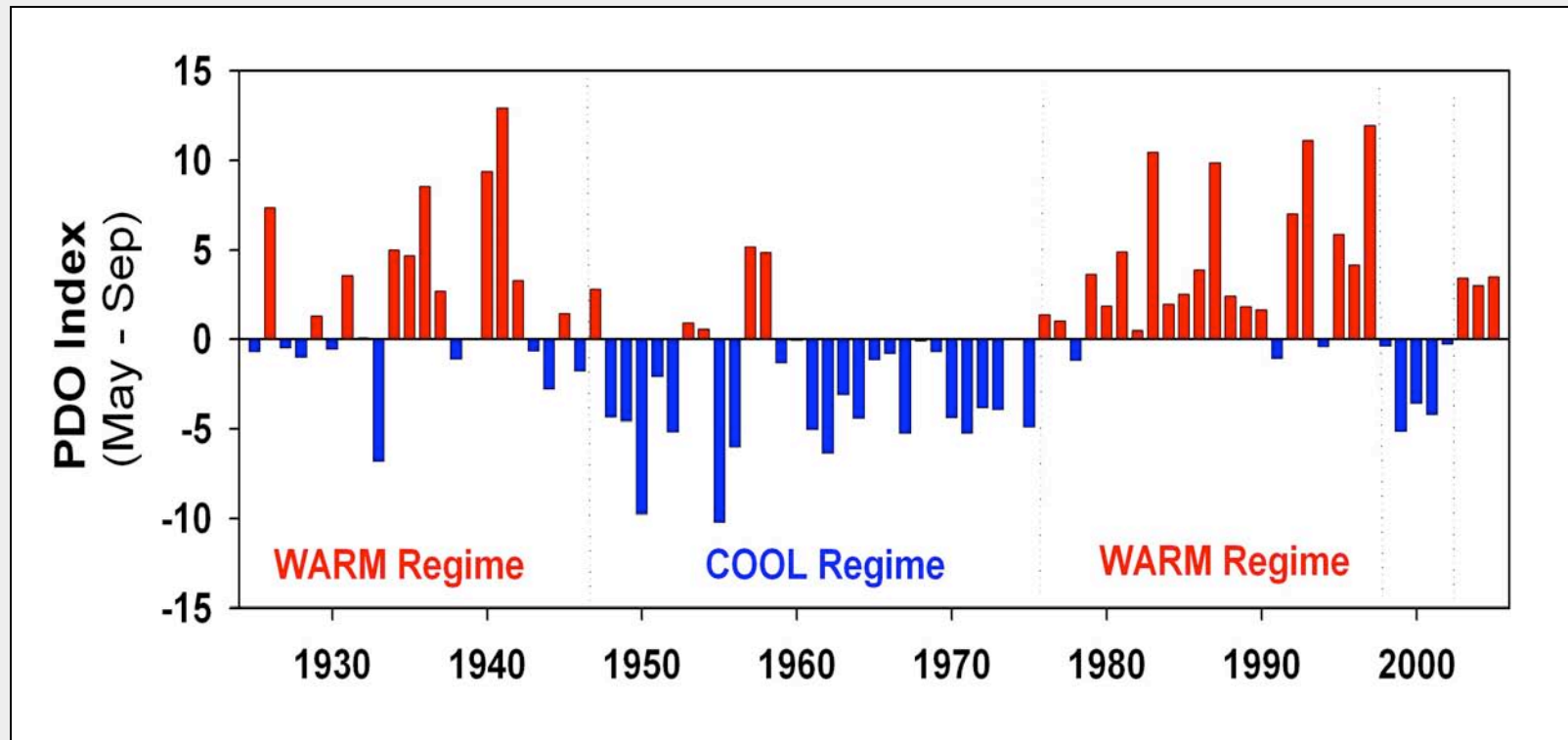
Source: NASA Goddard Institute for Space Studies



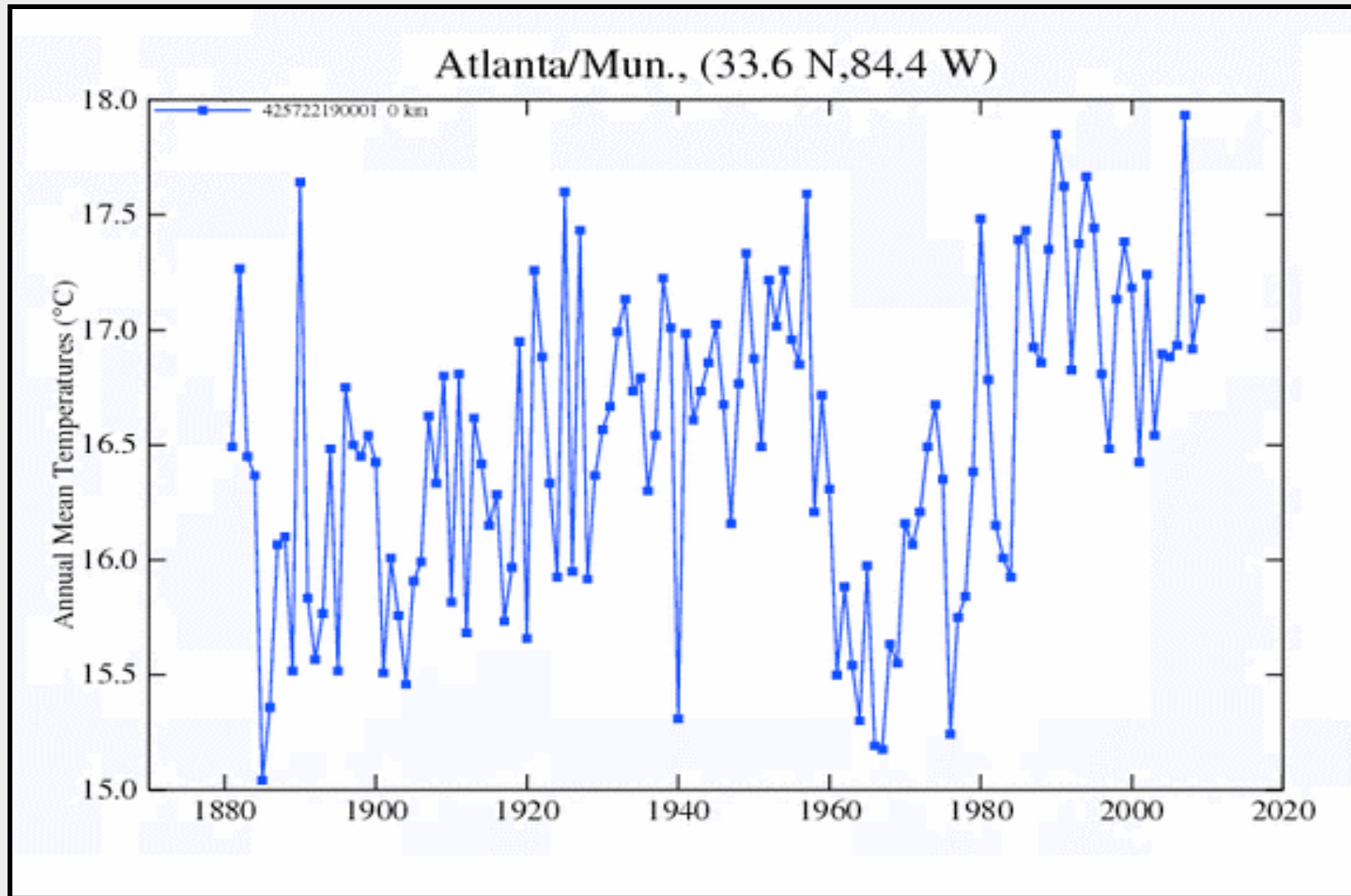
Source: NASA Goddard Institute for Space Studies



Pacific Decadal Oscillation (PDO)



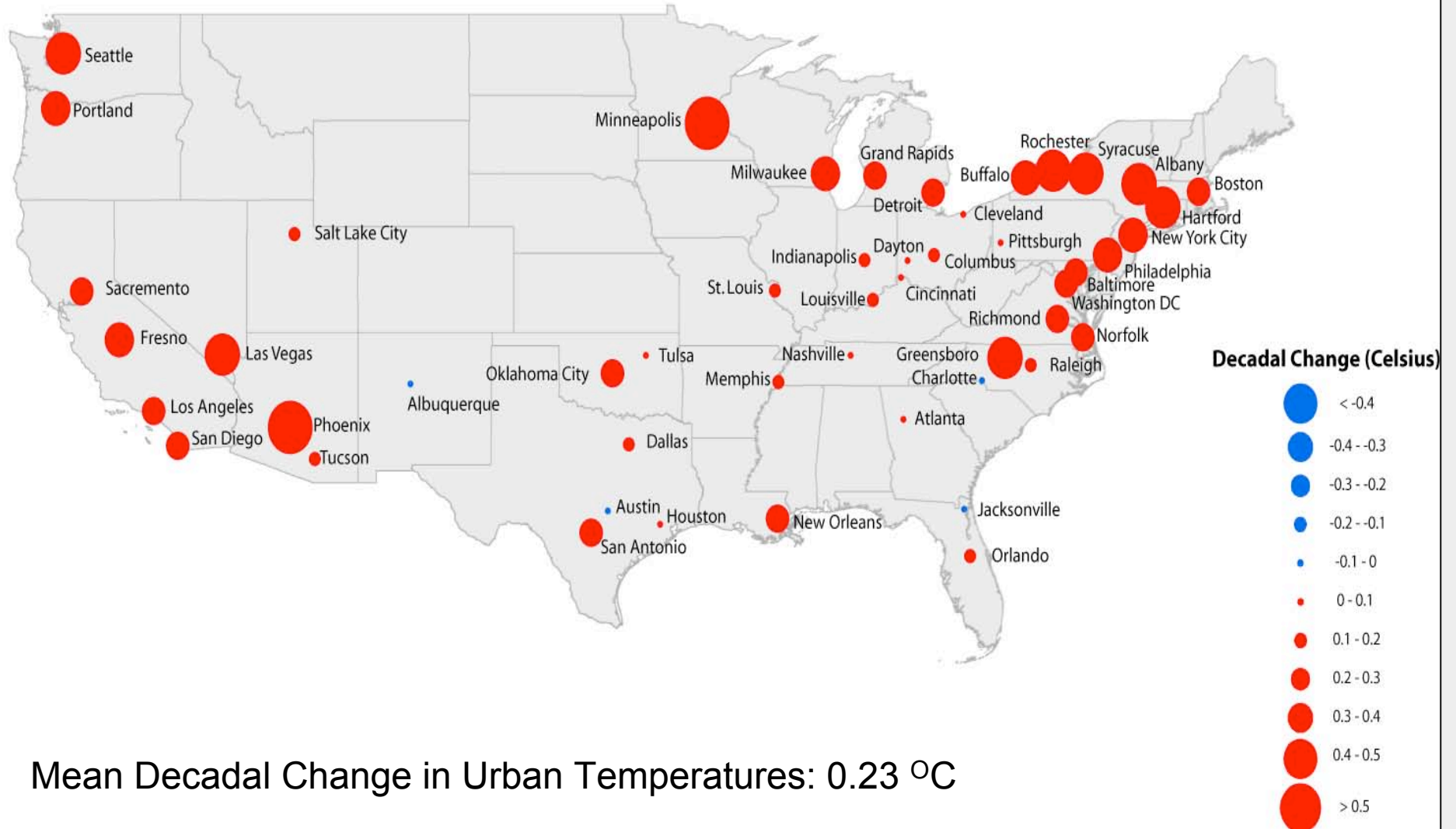
The Pacific Decadal Oscillation is a climate index reflective of patterns of variation in sea surface temperature of the North Pacific from 1900 to the present (Mantua et al. 1997). While derived from sea surface temperature data, the PDO index is well correlated with many records of climate and ecology, including sea level pressure, winter land-surface temperature and precipitation, and stream flow (NOAA Fisheries Service).



Source: NASA Goddard Institute for Space Studies, GHCN

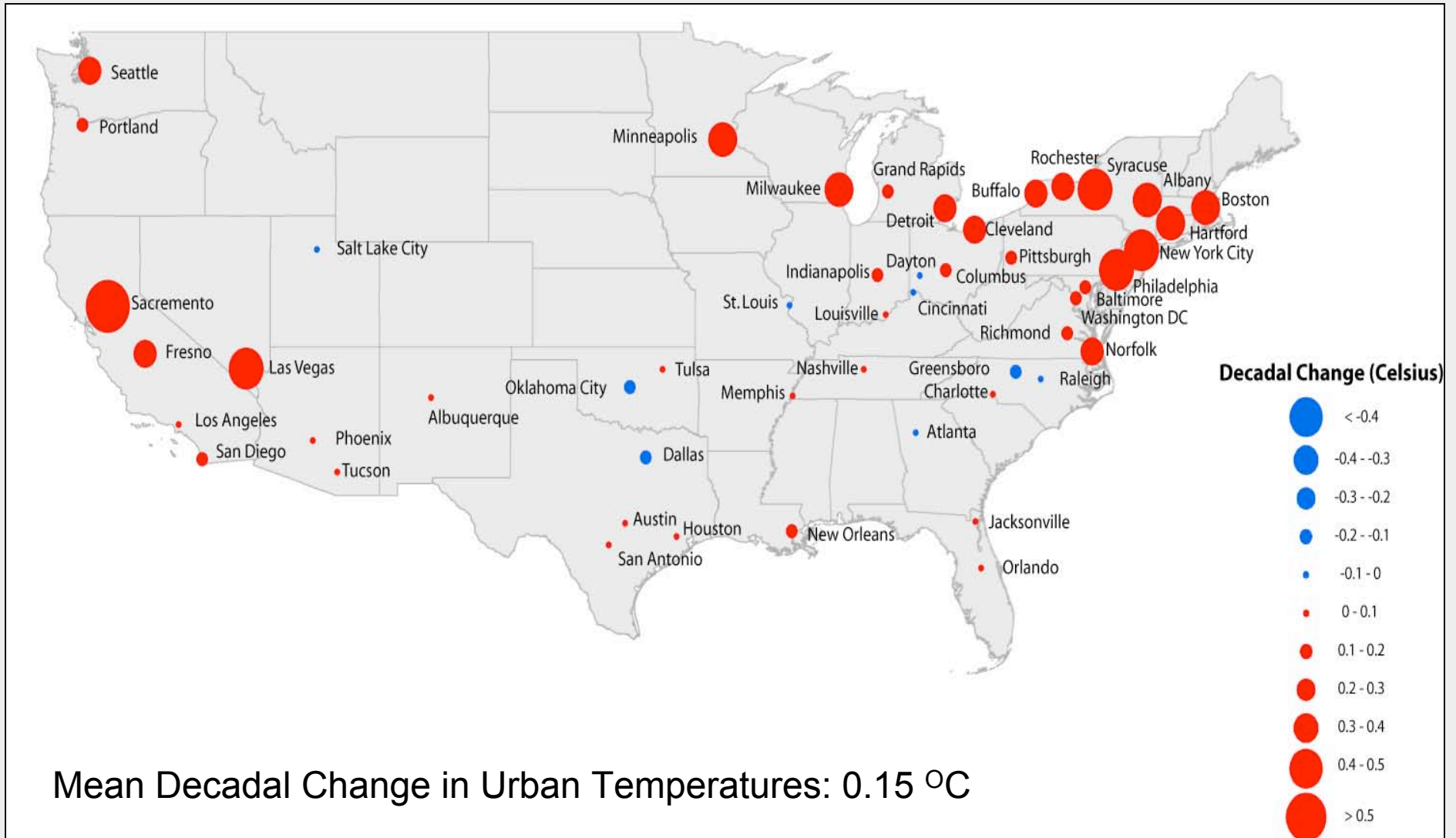


Urban Trends: 1957-2006



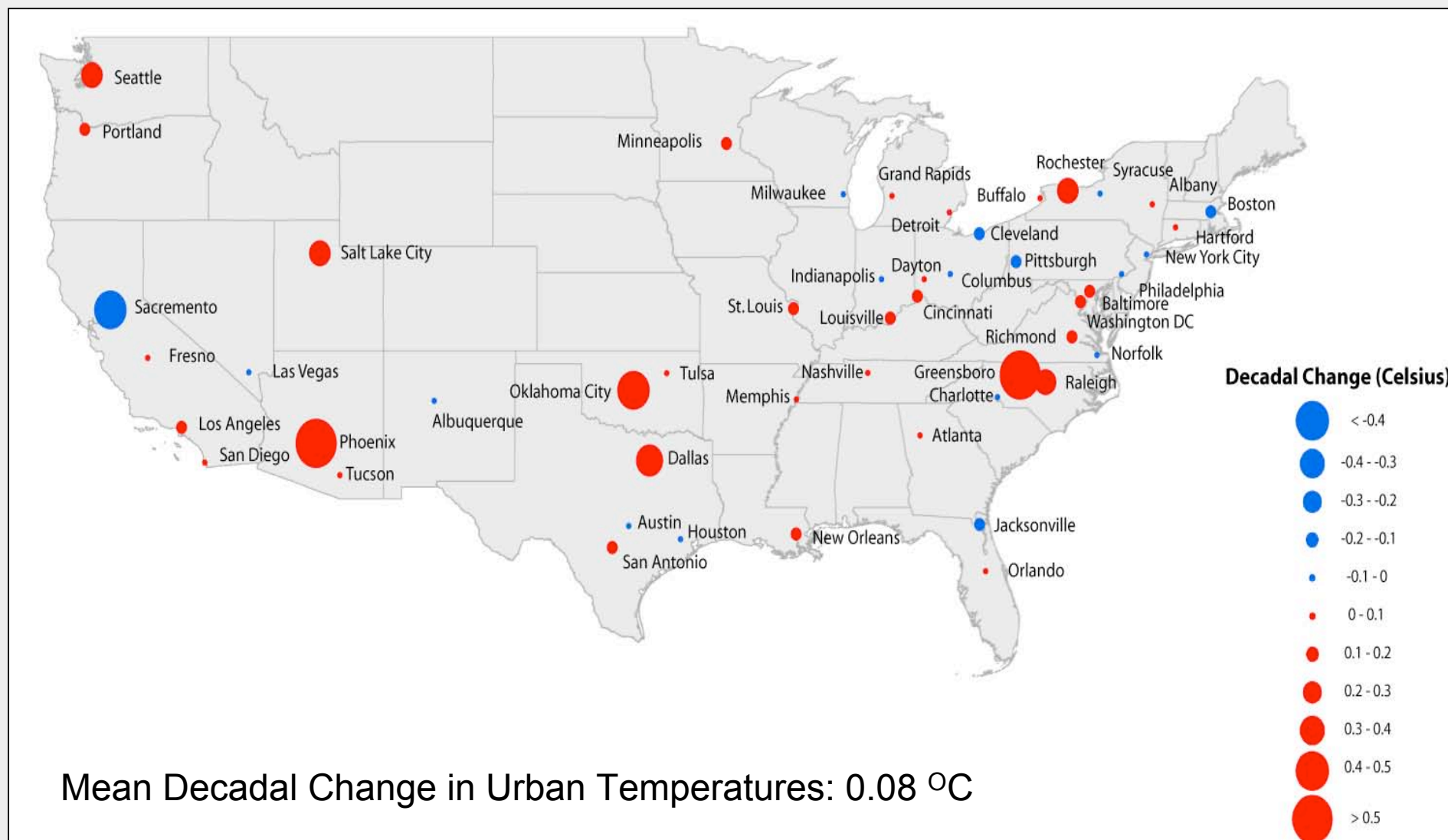


Rural Trends: 1957-2006



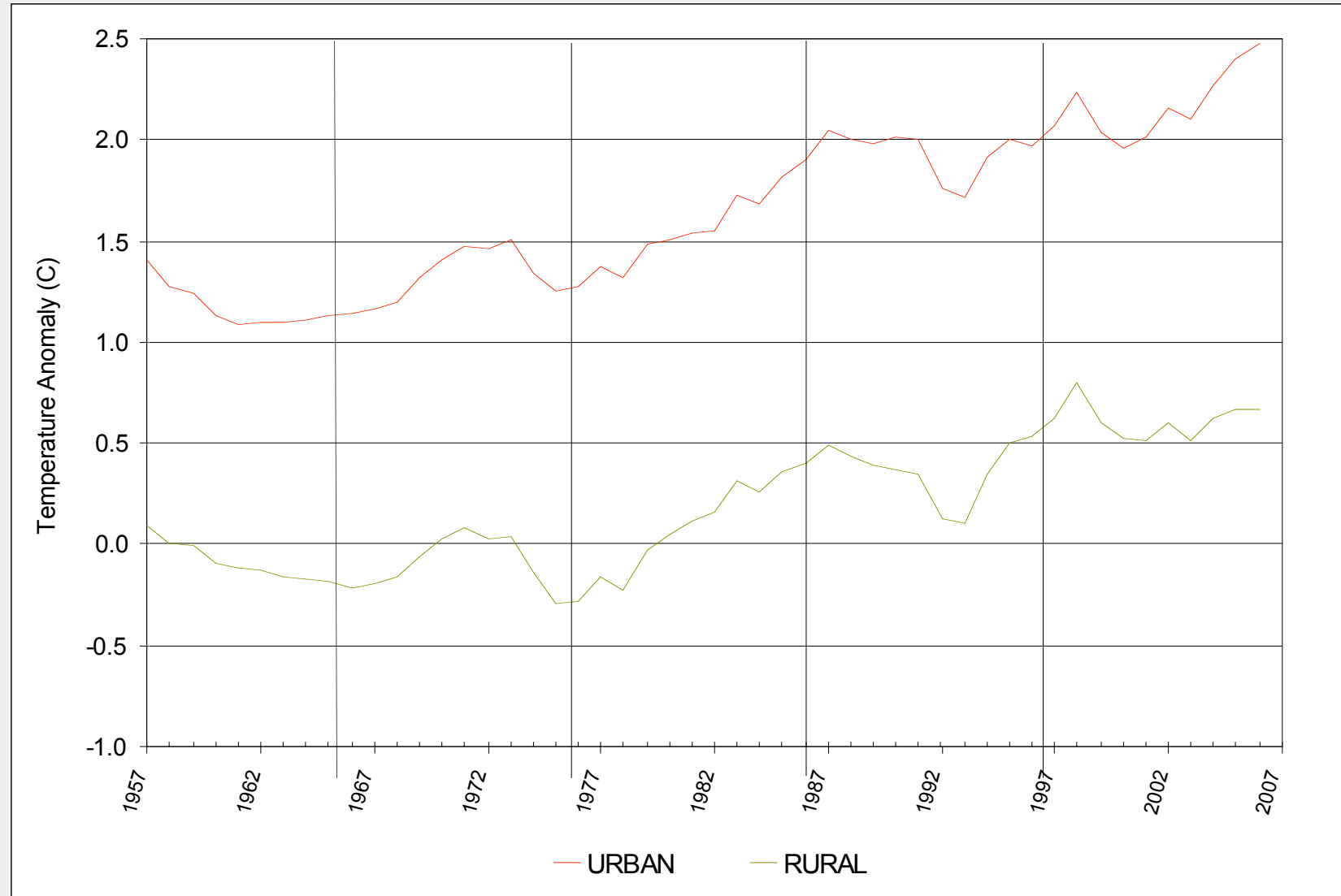


UHI Trends: 1957-2006





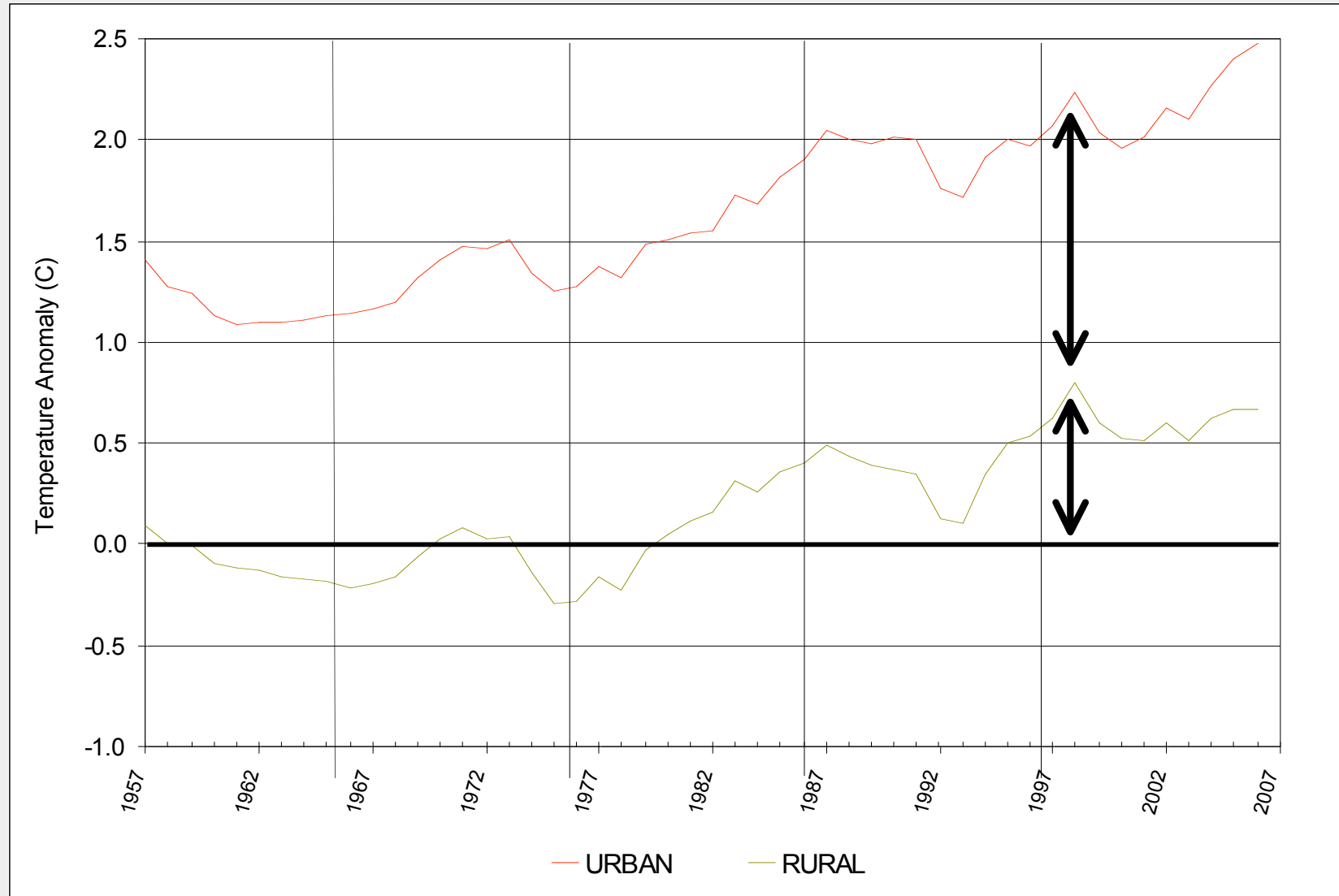
Urban and Rural Temperature Anomalies: 1957-2006



Temperature anomalies ($^{\circ}\text{C}$) relative to 1951-1980 mean.



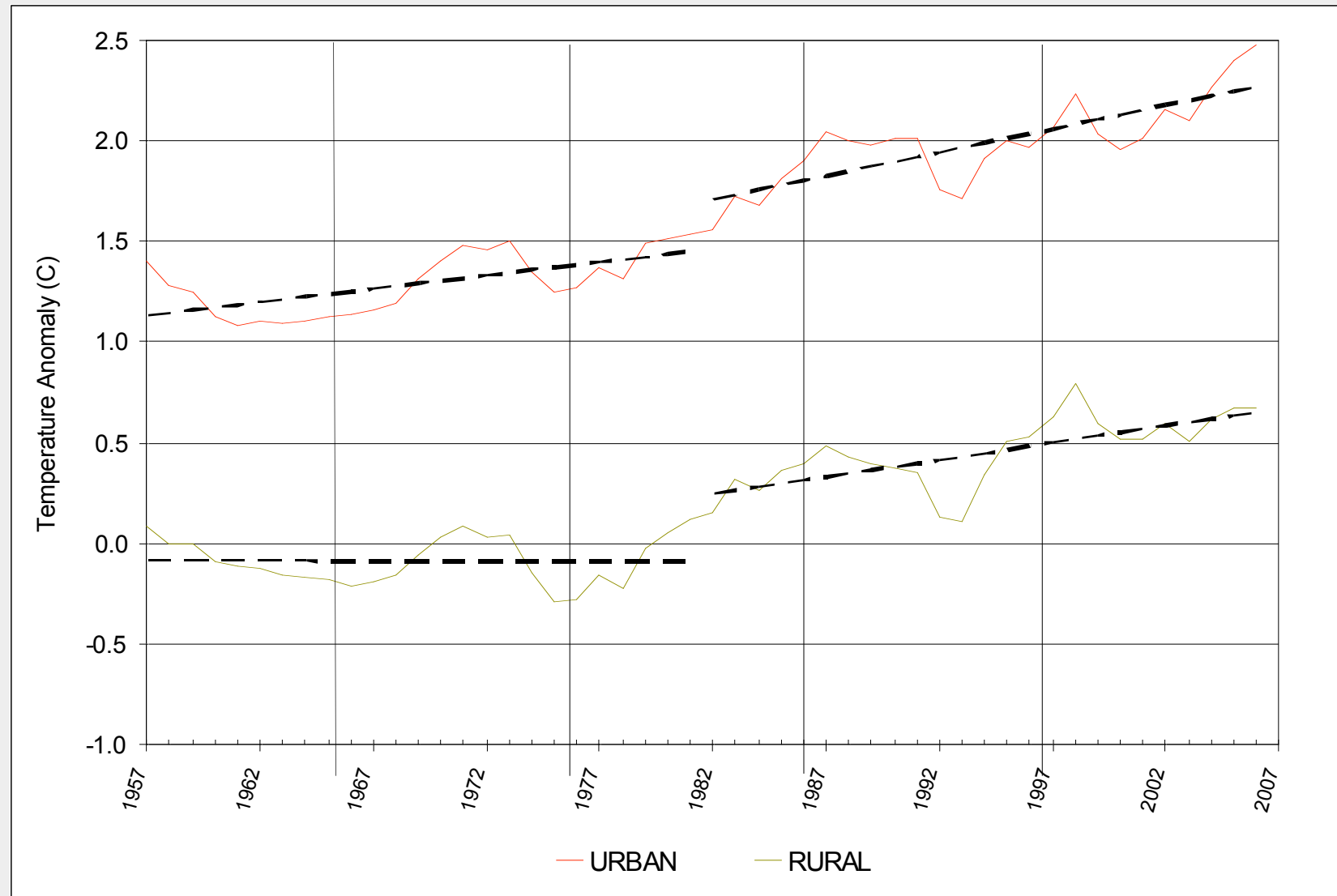
Urban and Rural Temperature Anomalies: 1957-2006



Temperature anomalies (°C) relative to 1951-1980 mean.



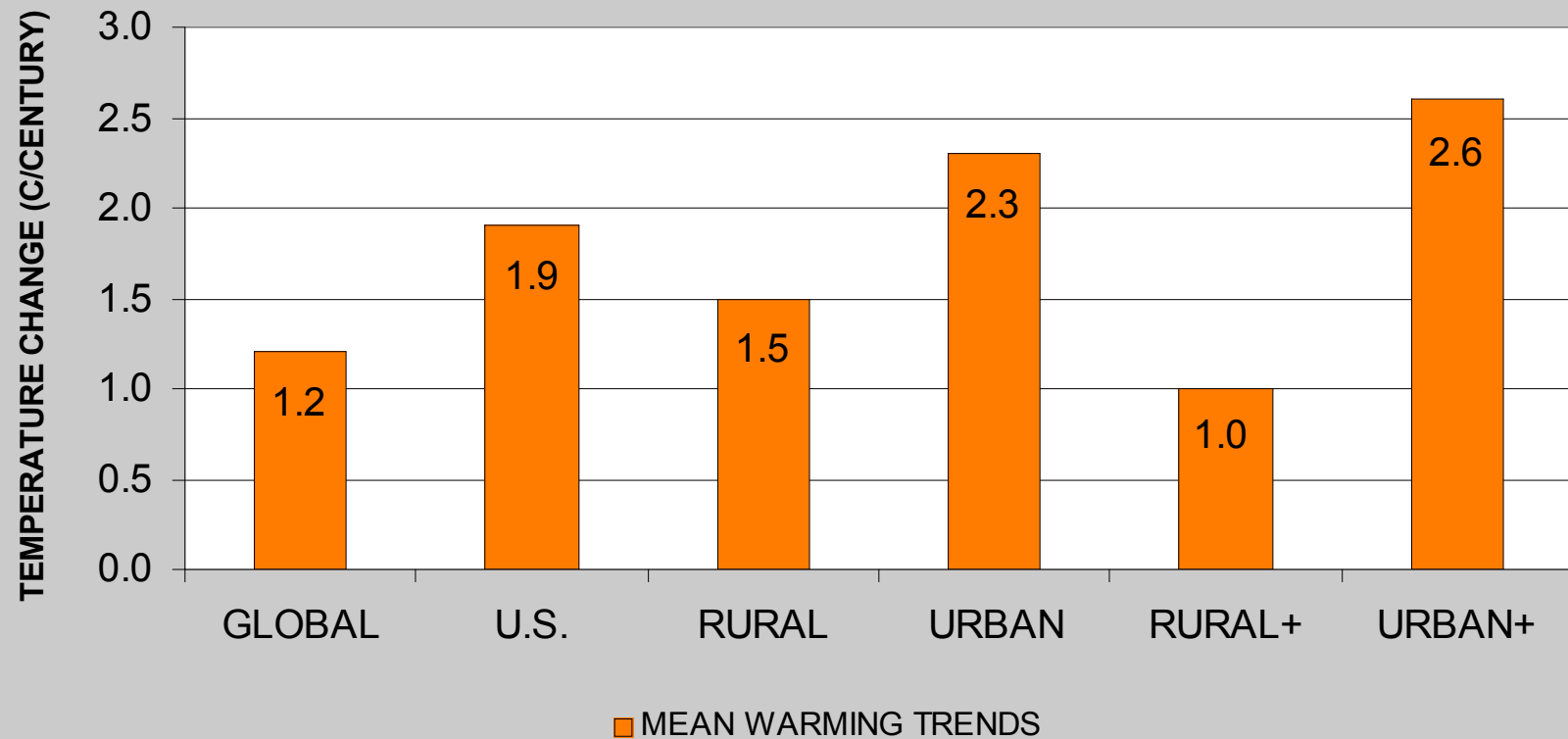
Urban and Rural Temperature Anomalies: 1957-2006



Temperature anomalies (°C) relative to 1951-1980 mean.



RATE OF TEMPERATURE CHANGE: 1957-2006



Source: NASA Goddard Institute of Space Studies
+ Cities in which UHI increased between 1957 and 2006

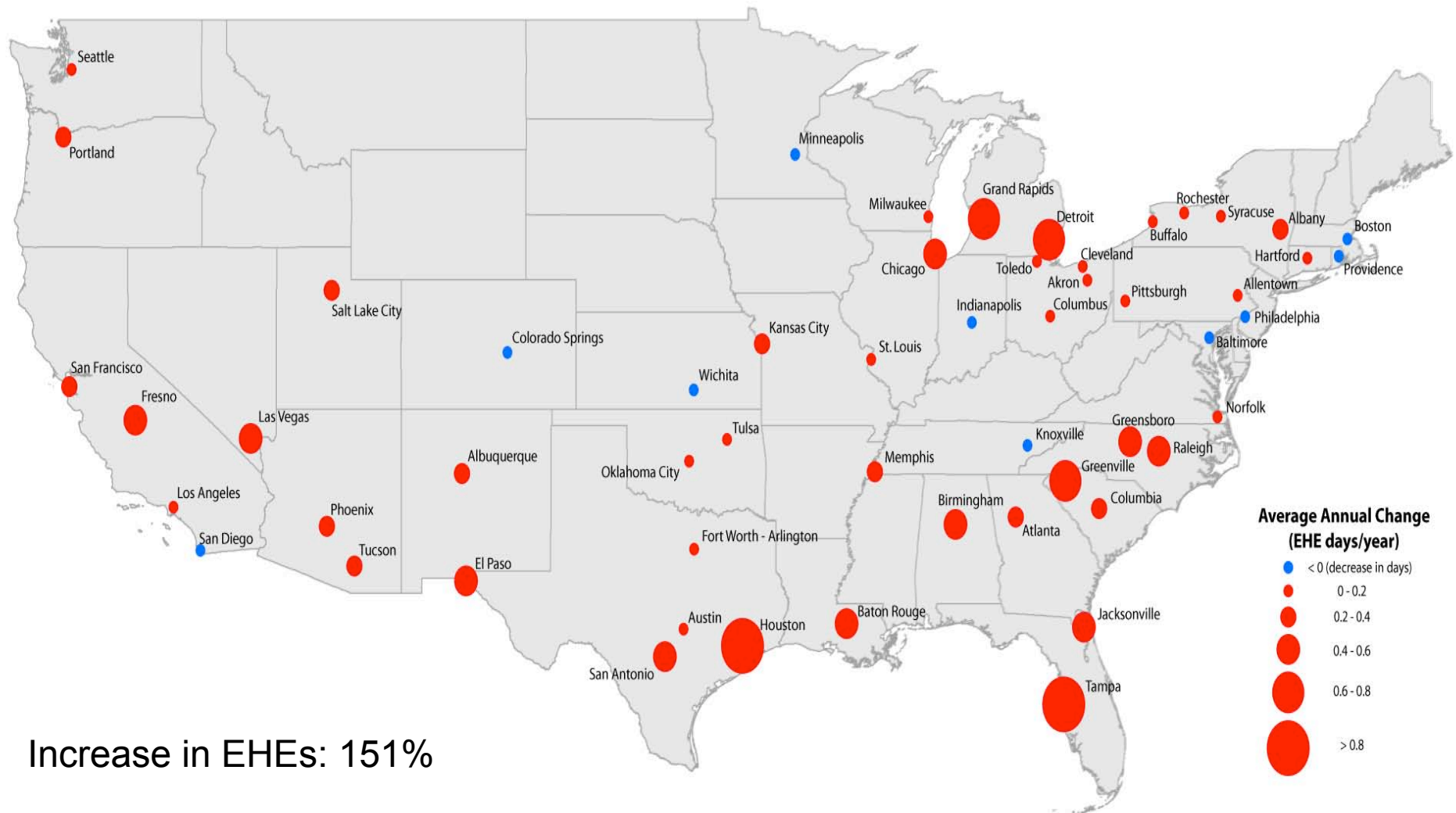


Study Findings

- On average, the decadal rate of warming in large U.S. cities was approximately 50% greater than that of proximate rural areas taken to represent “background” warming trends over the period of 1957-2006
- For cities in which the urban heat island effect intensified during this period (60%), the decadal rate of warming was approximately 160% greater than that of proximate rural areas
- As warming scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) are based on background global rates of warming, these scenarios (1.4 to 5.8 °C by 2100) are likely to significantly underestimate the rate of warming in large cities over time

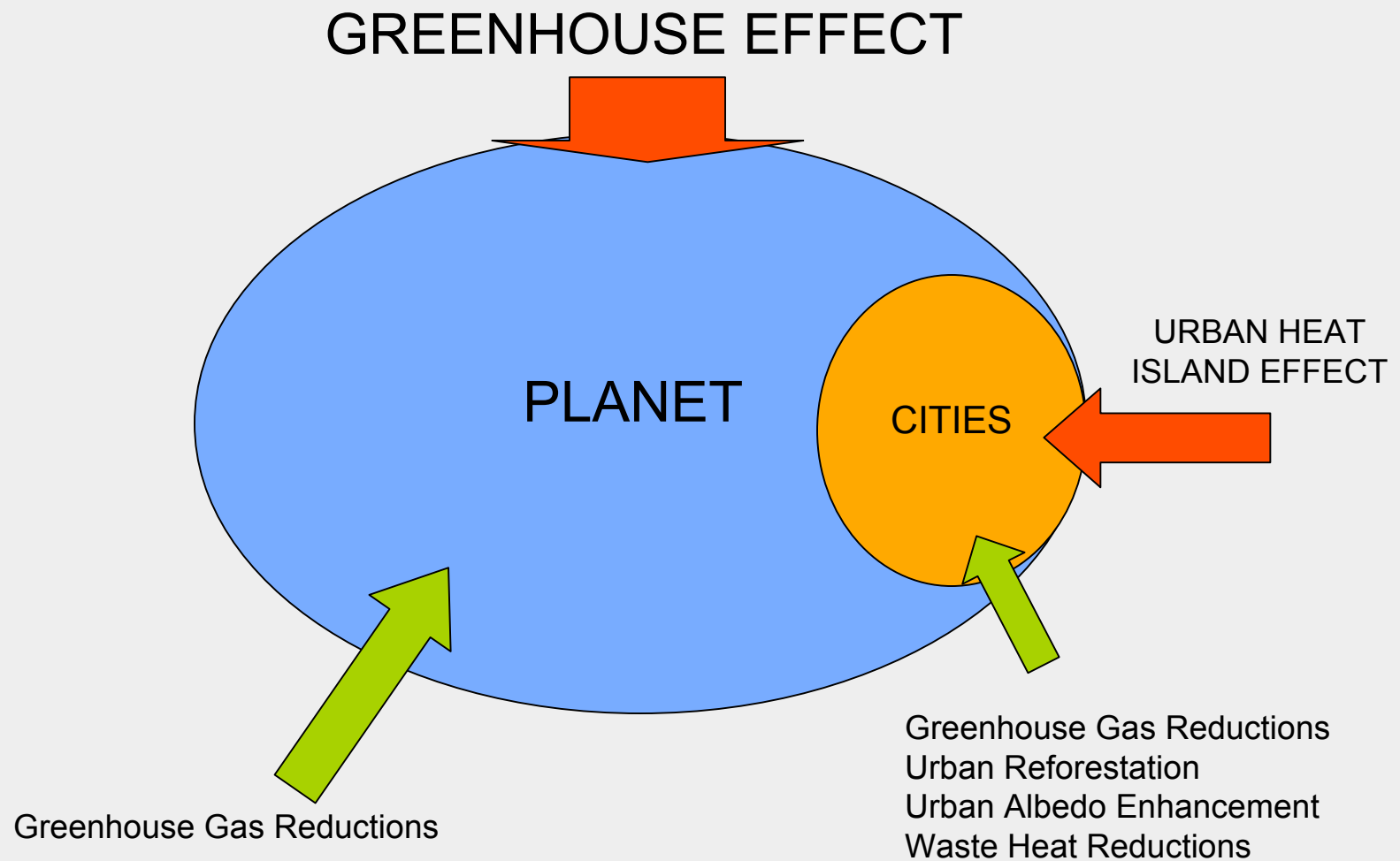


Change in Excessive Heat Events: 1956 - 2005

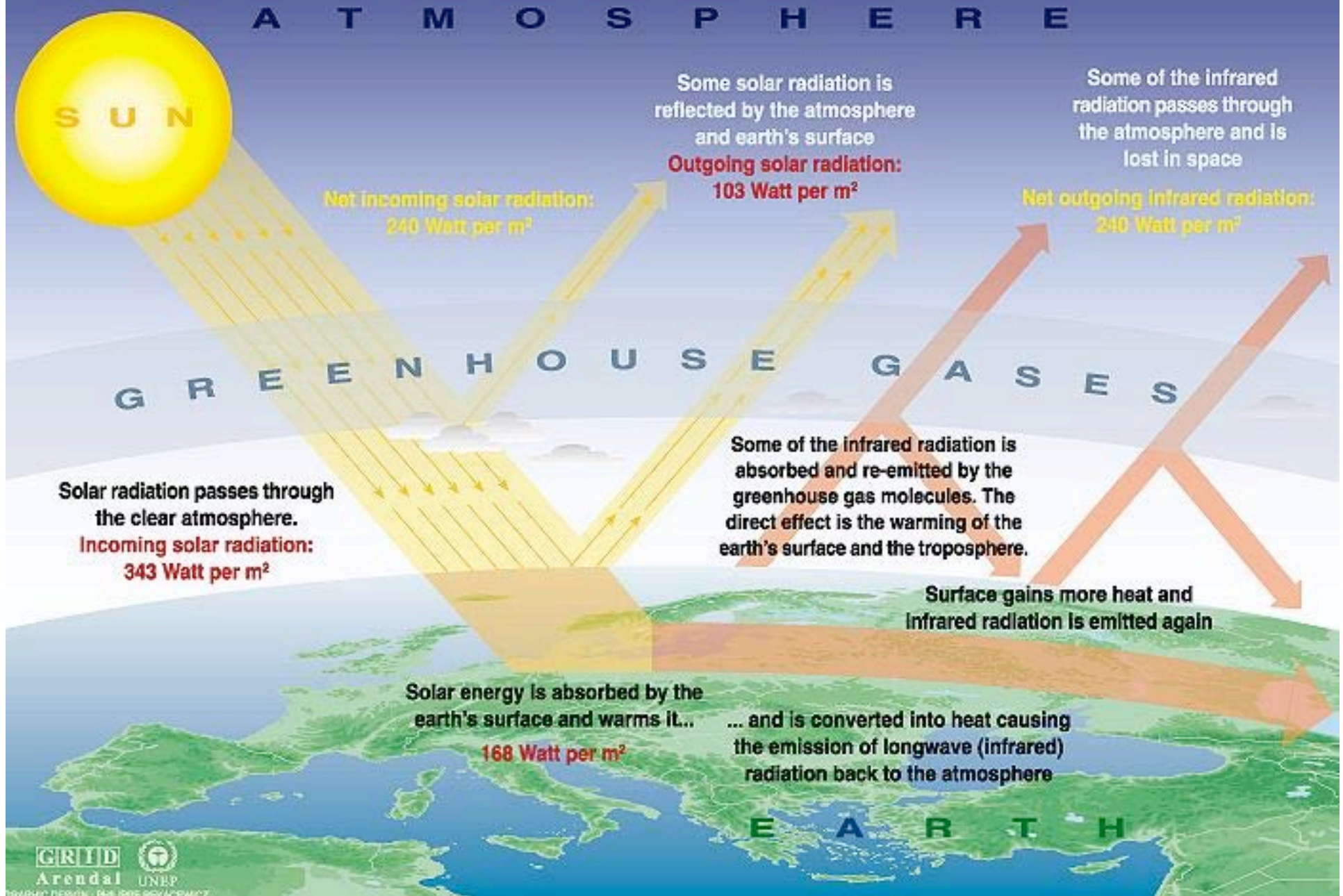




The Need for a Duality of Management Strategies in Cities



The Greenhouse effect





In the continental U.S., approximately 50% of the rise in near surface air temperatures since the 1960s is attributable to land use change.

Impact of urbanization and land-use change on climate

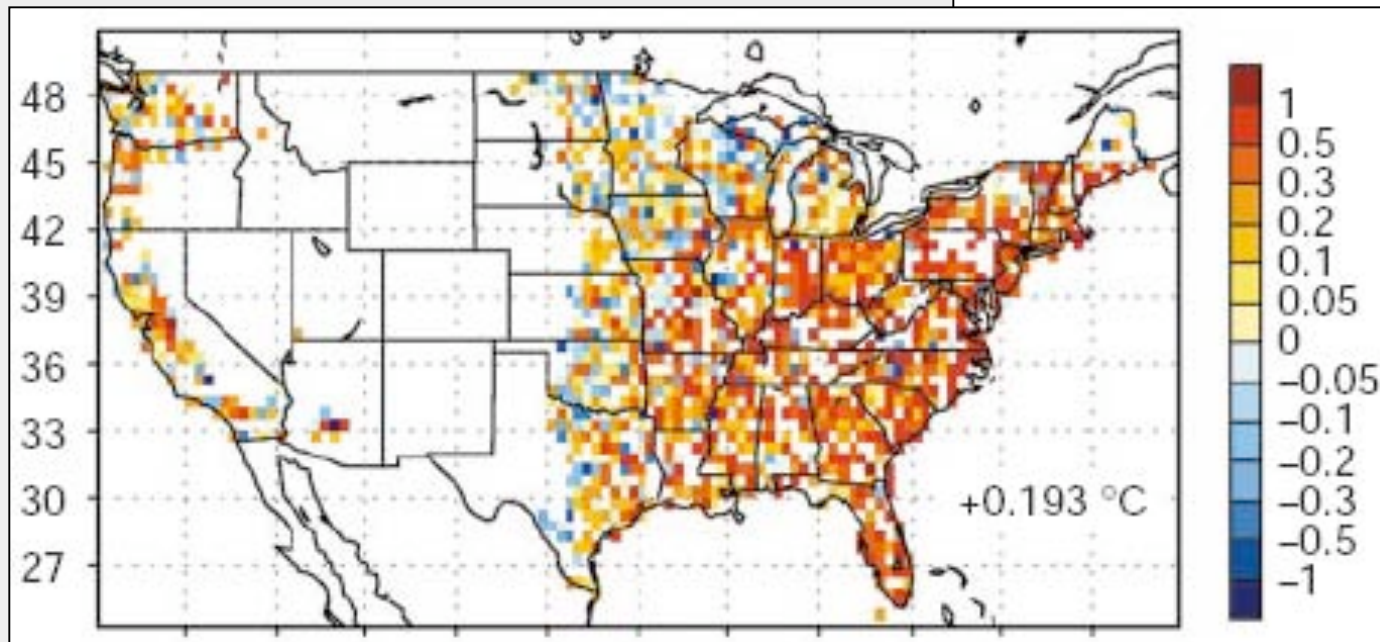
Eugenia Kalnay & Ming Cai

University of Maryland, College Park, Maryland 20770-2425, USA

The most important anthropogenic influences on climate are the emission of greenhouse gases¹ and changes in land use, such as urbanization and agriculture². But it has been difficult to separate these two influences because both tend to increase the daily mean surface temperature^{3,4}. The impact of urbanization has been estimated by comparing observations in cities with those in surrounding rural areas, but the results differ significantly depending on whether population data⁵ or satellite measurements of night light⁶⁻⁸ are used to classify urban and rural areas^{7,8}. Here we use the difference between trends in observed

continental United States and the detection of surface temperatures global weather over the past 50 observations, to estimate the surface warming. Our results increase in diurnal temperature land-use changes. Moreover, our warming per century due to

23 | 29 MAY 2003 | www.nature.com/nature



Source: Kalnay & Kai, 2003